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EFFECTS OF CHANGES IN ATMOSPHERIC PRESSURE ON FRUITS & VEGETABLES

(Tests conducted under
simulated flight conditions)

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Effects of Changes in Atmospheric Pressure on Fruits & Vegetables
(Tests conducted under simulated flight conditions)

The effect of altitude on fruits and vegetables is an important consideration in determining the need for pressurizing the cargo compartments of planes. This subject was of sufficient interest to the Prototype Working Group of the Civil Transport Aircraft Evaluation and Development Board to warrant study and a request was made to the Department of Agriculture in late October to develop information on the effect of altitude on perishable foods. The work on fruits and vegetables was done in California where freshly harvested produce of wide variety was still available. Of all of the fruits and vegetables tested, which included 34 separate items, only 2 showed injury that could be attributed to altitude. These were several specimens of large ripe tomatoes and one ripe persimmon out of several lugs of both that were tested during the simulated flights. The conditions under which the injury occurred were extremely severe, namely during ascent to 50,000 feet at a rate of 5,000 ft. per minute. The type of injury was splitting of the persimmon and tomato occurring between 45,000 and 50,000 ft. elevation (Fig. 1). Strawberries, grapes, peaches, figs, sweet corn, bell peppers, summer squash and limes exposed to the same elevations showed no injury.

These tests indicated that many fruits and vegetables became dull and unattractive during simulated flights, not because of altitude but because of warm temperatures and low humidities during the flight. Mold on berries made considerable growth during warm "flights". These observations point to the need of cool temperature and a moist atmosphere for the air transportation of many fruits and vegetables. Plane design should take into consideration these requirements for fruits and vegetables.

Test Procedure

Under the auspices of the Air Cargo Institute of California a meeting with air cargo specialists and aircraft manufacturers was held in Burbank on November 4 to outline the altitudes, rates of climb and descent that would represent transcontinental flights in planes of the near future. It was agreed that practical altitude tests should be at elevations not exceeding 20,000 ft. and that the chamber should be brought to sea level at 3 intervals during the test thus subjecting the perishables to 4 ascents and descents. The rates of climb and descent were to be at 1,000 ft. per minute. If any commodities showed injury, lower elevations were to be tried and if none showed damage more extreme conditions of altitude and rates of altitude change were to be employed. Non-precooled and precooled flights were to be made. Whenever practicable, commercial containers were to be used. Duplicate control lots of each commodity were to be held at temperatures and humidities similar to those in the altitude chamber so that any altitude effect could be evaluated by close comparison with the checks. Inspections were to be made at the end of the flight and a day or two later to determine differences in market life.

The facilities for conducting the tests were provided by the Lockheed Aircraft Corp. and the work was done cooperatively between this agency and the U. S. Department of Agriculture. The decompression chamber used to simulate flights permitted the control of altitude, rate of climb and descent, temperature and humidity. Fruits and vegetables for the tests were purchased by the U. S. Department of Agriculture from the Los Angeles wholesale market early in the morning, and if they were not to be precooled they were trucked to Burbank in less than an hour, inspected, weighed and placed in the altitude chamber. When precooling was desired the produce was held 24 hours at 40° in a precooling room at the market and the test was made the following day.

Eight tests were made, (table 1), two of which were at altitudes of 20,000 ft., 4 at 30,000 ft., one at 10,000 ft., and a final one at 50,000 ft. Temperatures of the produce and the air of the chamber were read during the test period with thermocouples and humidity records were obtained with a hygrothermograph placed in the chamber. Similar records were made in the rooms in which the control lots were held. Dial indicators were installed on tomatoes, peppers and avocados to show changes in diameter during the altitude test. Photographs of the decompression chamber and instruments used are shown in figures 2 to 4. The fruits and vegetables used in test A are shown in figure 5. Thirty-four different fruits and vegetables were tested as indicated below:

Asparagus
Avocados
Beans, string
Beans, lima
Beets
Bell peppers
Broccoli
Brussel sprouts
Carrots
Cauliflower
Celery
Cucumbers
Eggplants
Figs
Grapes
Limes
Mushrooms
Mustard greens
Onions
Parsley
Peaches
Peas
Pears
Persimmons
Radishes
Raspberries
Romaine lettuce
Salad mix
Spinach
Strawberries
Sweet corn
Squash, summer
Tomatoes
Water cress

Results

The results of the individual tests are presented in chronological order. Test A consisted of a "flight" to 20,000 ft. with rates of ascent and descent of 1,000 ft. per minute. Three descents were made during a 12 hour "flight", 8 hours of which was spent at 20,000 ft. (fig. 6). The produce was not precooled and air temperatures were about 80°F. the first 2 hours and then were 60° to 75° for the remainder of the test. Commodity temperatures were about 65°. Humidities were low, ranging from 25 to 30 percent. This was considered a warm dry flight and the condition of some of the commodities after the first 2 hours in the chamber showed the effects of it in dullness and wilting. Weight loss recorded during the 24 hour period encompassing the flight was high and some commodities, such as asparagus, broccoli and green onions, red raspberries and strawberries (table 2) showed losses ranging from 6 to 15 percent. Of the 31 commodities used in this test, only tomatoes showed any indication of altitude injury, and its cause was doubtful for the leaking and bruising may have been due to mechanical damage. The indicator gauges used on 3 specimens of tomatoes during the test showed expansion and contraction in 2 samples amounting to

15 to 30 thousandths of an inch which was quite small for a 3 to 3 1/2 inch tomato (fig. 6). Tomato A was punctured after the third "flight" but it still expanded on the next ascent. Peppers and avocados did not show expansion.

Test B was a duplication of test A in respect to altitude but commodity and air temperatures were maintained at about 42°F. and humidity at 55 to 70 percent (fig. 7). The fruits and vegetables were precooled to about 40° for this test. It was thought that produce if cold would be more turgid than if warm and would split more easily. No splitting was observed in any of the lots (table 3). The most noticeable result was the fresher appearance of the fruits and vegetables as compared with those in the previous test. The weight losses of several commodities during the 24 hours period including the "flight" in these two tests are compared below and the advantage of a cool, moist flight in retaining weight is evident.

	Weight Loss	
	Test A - non-precooled	Test B - precooled
	Pct.	Pct.
Asparagus	14.6	0
Red raspberries	5.8	0
Strawberries	6.9	1.5
Squash, summer	4.1	1.9

Tests C-1 and C-2 were exploratory, made to find whether elevations of 30,000 ft. would be damaging to fruits and vegetables. The first flight was made at a rate of 3,000 ft. per minute ascent and descent and the second at 2,000 ft. per minute. Both were cool flights of 35 to 45°F. Duration at 30,000 ft. was 20 minutes in C-1 and 30 minutes in flight C-2. Red raspberries, strawberries, pears (Comice), tomatoes, cucumbers, figs (Brown Turkey), grapes (Muscat and Tokay), string beans, Zucchini squash and sweet corn (husked) were used and they were exposed to both flights. None of these fruits or vegetables showed injury.

Tests D and E were flights to 30,000 ft. with ascent and descent rates of 2,000 and 1,000 ft. per minute, respectively. The fruits and vegetables were held at 30,000 ft. for 2 hours in both tests. Temperatures were 38° to 43°F. and humidities 80 to 88 percent in test D and 35 to 50 percent in E. The following day another sample of the same lots of fruit was "flown" at 10,000 ft. (i.e. in a pressurized cabin "flight") for 5-1/4 hours with rates of ascent and descent of 500 ft. per minute. It was a cool flight at 44° to 57°F. but farily dry, 32 to 53 percent humidity. The condition of the produce from this test and tests D and E is compared with that of the check lots in table 4. With only one exception none of the commodities showed injury that could be attributed to altitude. Some large specimens of ripe tomatoes showed cracking of the skin in tests E and F. It is strange that the lot exposed to only 10,000 ft. should show injury (test F) whereas one lot, exposed to 30,000 ft. (test D) did not. Weight losses were moderate in all three tests.

Test G was a final one made on November 24 with the check fruit from the previous test. The produce was brought to an elevation of about 49,500 ft. and held there for 30 minutes. Ascent rates were 5,000 ft. per minute up to 40,000 ft., diminishing as higher elevations were reached. Descent was at the rate of 5,000 ft. per minute. The air temperature was close to 50°F. and humidity 40 to 70 percent. One tomato and a persimmon showed splitting when 48,000 ft. was reached. The split of the persimmon closed appreciably during descent. Dial gauges placed on a tomato showed expansion of about .023 inches at an elevation of 48,500 ft. Small tomatoes and other commodities used in the test were not injured.

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Table 1 - Test conditions used during simulated flights.
Lockheed decompression chamber, Burbank, California, Nov. 10-24, 1948.

Test	Test altitude	Total time at alt.	Total test time	Climb and descent rate	Temperature and Humidity				
					In decompression chamber			During subsequent storage	
					Temperature		Rel. hum.	Air temp.	Rel. hum.
	Ft.			Ft. per min.	Commod. °F	Air °F	Pct.	°F	Pct.
A	20,000	8 hrs. (4, 2-hr. periods)	12 hrs.	1,000	62 to 72	57 to 83	24 to 31	75	35
B	20,000	8 hrs. (4, 2-hr. periods)	11 hrs. 45 min.	1,000	40 to 44	41 to 45	54 to 70	70 to 73	40 to 48
C-1	30,000	20 min.	42 min.	3,000	50 to 60	35 to 41	60 to 98	70 to 73	40 to 45
C-2	30,000	30 min.	1 hr.	2,000	40 to 60	37 to 47	50 to 70	70 to 73	40 to 45
D	30,000	2 hrs.	2 hrs. 31 min.	2,000	42 to 64	38 to 43	80 to 88	40 to 48	50 to 80
E	30,000	2 hrs.	2 hrs. 53 min.	1,000	44 to 61	38 to 43	35 to 70	40 to 48	50 to 80
F	10,000	5 hrs. 15 min.	6 hrs.	500	46 to 55	44 to 57	32 to 53	40 to 48	50 to 80
G	50,000	30 min.	1 hr.	5,000	47 to 53	46 to 57	40 to 70	(not held)	

Table 2. Effect of altitude on fruits and vegetables in test A, Lockheed decompression chamber, Burbank, Calif., November 10, 1948. ("Flight" conditions: climb 1,000 ft. per min. to 20,000 ft. hold for 2 hrs. descend same rate to sea level, hold 20 min. repeat 4 times. Air temp. of chamber 70-80° F., humidity approx. 30%, check samples held 75° F., 35% r.h.).

Commodity	Container	Weight		Weight loss [1/]		Condition of produce after exposure to altitude test.
		Lbs.	Oz.	1st day; Pct.	1st & 2nd day Pct.	
Asparagus, Imperial Valley, Mary Washington	1/2 crate	18	0	14.6	16.6	No injury, slightly more wilting in altitude test lot first day, both wilted and shrivelled second day.
Check lot	do.	15	6	3.3	6.6	
Avocado, Fuerte and Puebla	Flat	13	13	3.2	4.5	No injury to either variety, same appearances as check. Fuerte firm, bright; Puebla slightly soft by 2nd day.
Check lot	do.	13	1	2.4	4.3	
Beans, Lima and Green	Lug	22	5	3.4	5.6	No injury, same as check on first day, both dull second day, slightly more wilting in altitude test lot.
Check lot	do.	23	14	1.8	4.2	
Broccoli and Bunched Onions	do.	14	0	6.7	10.0	No injury to either broccoli or onions, slightly more wilting of tops of onions in altitude test lot, broccoli shows wilting, yellowing both lots.
Check lot	do.	15	6	3.2	6.4	
Brussel sprouts, spinach, salad mix, 6 transparent bags of each	do.	16	5	2.7	4.6	No injury, spinach shows slight wilting in altitude test lot; sprouts, salad mix fresh first day, slight yellowing of sprouts, wilting of salad mix 2nd day.
Check lot	do.	15	5	1.6	4.1	
Cauliflower (trimmed); egg plant	do.	--	--	--	--	No injury, cauliflower, white, fresh first day, slightly yellowed 2nd day both lots; egg plant bright, fresh, slightly soft 2nd day both lots.
Check lot	do.	--	--	--	--	
Cucumbers (waxed, prepackaged) celery in pliofilm bags.	do.	--	--	--	--	No injury, cucumbers dull, greasy from waxing (?) both lots; celery white and crisp both lots for 2 days.
Check lot	do.	--	--	--	--	

Table 2. - Continued

Commodity	Container	Weight Lbs.	Weight Oz.	Weight Loss 1/ 1st day; Pct.	Weight Loss 1/ 1st & 2nd day Pct.	Condition of produce after exposure to altitude test.
Figs, Brown Turkey	Flat	15	3	2.9	4.1	No injury, slightly soft first day; 10 percent decay in check lot 2nd day, altitude test lot shows no decay but more shrivel.
Check lot.	do.	14	15	1.7	3.8	
Grapes, Muscat of Alexandria	Lug	37	7	0.6	0.8	No injury, both lots fresh, sound.
Check lot	do.	36	3	0.5	0.5	
Grapes, Flame Tokay	do.	34	11	0.7	1.1	No injury, both lots fresh, sound.
Check lot	do.	32	6	0.8	1.2	
Mushrooms, Button	Six 8 oz. boxes	--	--	--	--	No injury, both lots fairly white on first day but slightly browned by 2nd day.
Check lot	Four 8 oz. boxes	--	--	--	--	
Peaches, Cucamonga Freestones	Lug	25	12	1.0	1.9	No injury, both lots fairly firm, no pitting on first day, on second day altitude lot softer than check lots.
Check lot	do.	26	0	1.0	1.9	
Peas, Telephone	Lug	14	15	3.3	5.4	No injury, altitude test lot slightly more wilted than check lot at both inspections.
Check lot	do.	15	7	2.8	4.9	
Peppers, Bell	Lug	19	3	1.0	2.3	No injury, both lots fresh, bright on first day, on 2nd day slightly more shrivel on shoulder of altitude test lot.
Check lot	do.	19	8	1.0	1.3	
Persimmons, ripe Hachiya	Lug	24	3	1.0	1.5	No injury, both lots bright, slightly soft, no pitting, by 2nd day both lots soft ripe.
Check lot	do.	24	4	0.5	1.3	

Table 2. - Continued

Commodity	Container	Weight Lbs.	Weight Oz.	Weight loss[1] 1st day; Pct.	Weight loss[1] 1st & 2nd day Pct.	Condition of produce after exposure to altitude test.
Radishes, carrots, beets, endive, watercress, parsley, mustard (6 bunches each lot)	Mixed crate	--	--	--	--	No injury, but all of these vegetables show serious wilting from the low humidities at which they were held.
Check lot	do.	--	--	--	--	
Red raspberries (San Martin) (Casberry)	12 basket crate	9	11	5.8	9.7	No injury, berries soft with some mold starting in both lots, slight leaking in check first day, by 2nd day no leaking in altitude lot, 10-20% mold in both.
Check lot	do.	9	0	3.5	7.6	
Squash, zucchini and white button or Cymlings	Lug	29	4	4.1	5.8	No injury, Zucchini squash shows more wilting in altitude test lot by 2nd day, button squash bright fresh both lots first day, wilted, pitted both lots 2nd day.
Check lot	do.	28	15	1.7	3.7	
Strawberries, (Sunol) 20th Century(dry, firm)	12 basket crate	13	8	6.9	12.0	No injury, no leaking, altitude test lot slightly duller than check, by 2nd day both lots unsalable, about 50% decay.
Check lot	do.	12	13	2.4	10.2	
Strawberries(Santa Maria) Klondike (soft berry)	do.	13	15	5.8	10.7	No injury, slight leaking in both lots, altitude test lot less bright than check, by 2nd day both lots unsalable 50-80% mold.
Check lot (Watsonville)	do.	13	6	3.3	6.6	
Sweet corn(Borego Springs) Golden Bantam Cross	Lug	20	12	1.8	4.8	No injury, both lots fairly fresh, some yellowing of kernels noted on husked ears in altitude lot, by 2nd day same as check, some drying.
Check lot	do.	21	8	5.2	8.1	
Tomatoes (El Segundo) Large, firm ripe to ripe, stem attached	Lug	28	12	0.7	1.1	Possible slight injury, bottom layer of tomatoes in altitude lot show leaking from pressure bruises 2nd day's inspection.
Check lot	do.	24	13	0.3	1.0	

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[1] Fruits and vegetables weighed just prior to test started at noon November 10 and re-weighed the following morning after test "flight". Second weighing made November 12 after holding a day at 75°, 35% r.h. Losses expressed as percent of original gross weight.

Table 3. Effect of altitude on fruits and vegetables in test B, Lockheed decompression chamber, Burbank, California, November 16, 1948. ("Flight" conditions: climb 1,000 ft. per min. to 20,000 ft. hold for approx. 2 hrs., descend same rate to sea level and hold 20 minutes, repeat 4 times. Produce precooled 20 hours in cold storage to 42° F. before "flight." Air temperature in chamber approx. 45° F., humidity 60 to 70%. Check lots held in cold storage during "flight" period.)

Commodity	Container	Weight Lbs.	Weight Oz.	Weight loss [1] 1st period Pct.	Weight loss [1] 1st & 2nd periods Pct.	Condition of produce after exposure to altitude test.
Asparagus, Imperial Valley, Mary Washington	1/2 crate	17	8	0	1.1	No injury. Both lots fresh, green 1st day; wilted and flowering 2nd day.
Check lot	do.	16	4	0	2.7	
Beans-String, Coachella Valley, Blue Lake	Lug	20	12	1.2	3.3	No injury. Both lots fresh, green 1st day; fairly fresh, no shrivel 2nd day.
Check lot	do.	20	6	1.5	3.7	
Beans-Lima, Ventura, Fordhook	do.	21	3	1.8	3.5	No injury. Both lots fresh, green 1st day; fairly fresh, no shrivel 2nd day.
Check lot	do.	22	3	.3	2.0	
Cucumbers, Delano Large 8"	do.	39	11	.3	.9	No injury. Both lots fresh, bright 2nd day.
Check lot	do.	33	12	.2	.7	
Figs, So. California Brown Turkey	1/2 Flat	10	4	1.2	3.1	No splitting or leaking. Both lots soft ripe, altitude test lot slightly more shrivelled than check on 1st and 2nd days.
Check lot	do.	10	1	.6	3.1	
Grapes, Fresno, Muscat of Alexandria	Lug	40	11	.2	.8	No splitting or leaking. Both lots fairly firm, stems slightly dry; stems of altitude test lot slightly browner than check on 2nd day.
Check lot	do.	40	13	0	.5	
Grapes, Lodi, Flame Tokay	do.	32	4	.6	1.0	No splitting or leaking. Both lots bright firm; stems fairly fresh on 2nd day.
Check lot	do.	32	2	.2	.8	

Table 3 (Continued)

Commodity	Container	Weight Lbs.	Weight Oz.	Weight loss 1/ 1st period Pct.	Weight loss 1/ 1st & 2nd periods Pct.	Condition of produce after exposure to altitude test.
Pears, Placerville, Bartlett (firm ripe)	Lug	25	12	.2	.5	No injury. Both lots yellow, ripe, with many dark brown spots on skin following unavoidable jolting during handling.
Check lot	do.	25	10	0	.2	
Pears, San Jose, Comice (firm ripe)	do.	26	3	0	.2	No injury. Both lots straw-russet, ripe, with very few bruised spots.
Check lot	do.	26	9	0	0	
Peas, Hayward Telephone	do.	16	2	2.3	4.7	No injury. Both lots fresh, green 1st day; fairly fresh, no shrivel 2nd day.
Check lot	do.	16	10	.8	3.0	
Peppers, San Jose Large Bell	do.	18	10	0	1.0	No injury. Both lots fresh, bright on 2nd day.
Check lot	do.	17	3	0	.4	
Red raspberries, San Martin Cayberry	1/2 crate	8	12	0	2.1	No splitting or leaking. Both lots soft, dull with a few flattened "sacs" or drupelets. Both lots salable on 2nd day.
	do.	8	6	0	.7	
Squash, Calipatria. Button or Cymling	Lug	33	2	1.5	2.6	No injury. Both lots fresh, bright 1st day; altitude test lot slightly more browned than check on 2nd day.
Check lot	do.	33	2	.6	2.5	
Squash, Dinuba Zucchini	do.	30	3	1.9	2.9	No injury. Both lots fresh, bright, slightly pitted. Altitude test lot slightly more wilted than check on 2nd day.
Check lot	do.	28	7	.9	2.4	
Strawberries, Sunol 20th Cent. (dry, firm)	12 basket crate	12	10	1.5	4.5	No splitting or leaking. Both lots firm, slightly dull, with some watery spots on surface. Unsalable 2nd day, moldy. Altitude test lot slightly more shrivelled than check.
Check lot	do.	13	6	5.1	7.9	

Table 3 (Continued)

Commodity	Container	Weight Lbs.	Weight Oz.	Weight loss[1] 1st period Pct.	Weight loss[1] 1st & 2nd periods Pct.	Condition of produce after exposure to altitude test.
Strawberries, Santa Clara University (Semi-dry)	12 basket crate	13	14	4.5	7.2	No splitting or leaking. Both lots firm, dark, dull; many with watery spots. Unsalable 2nd day due to mold and watery spots.
Check lot	do.	14	4	2.6	4.8	
Strawberries, Santa Maria Klondike (soft)	do.	13	10	5.0	7.3	No splitting or leaking. Both lots fairly firm, bright; most with watery spots. Unsalable 2nd day due to mold and watery spots. Altitude test lot slightly more shrivelled and duller than check.
Check lot	do	14	3	4.4	6.6	
Sweet Corn, Arvin Golden Cross	Crate	43	11	4.9	7.6	No injury. Both lots fairly fresh, kernels plump, no shrivel 2nd day.
Check lot	do.	47	0	2.9	6.6	
Tomatoes, El Segundo Large, firm ripe, stems attached.	Lug	26	4	.2	1.0	No splitting or leaking. Both lots firm ripe 1st day; fairly firm, no shrivel 2nd day.
Check lot	do.	26	6	0	.5	

[1] Fruits and vegetables weighed prior to precooling Nov. 15, re-weighed Nov. 17 after altitude test and holding overnight in cool chamber. Final weighing Nov. 18 after holding 24 hours in a warm room. Check lots held in cold room until Nov. 17. Losses expressed as percentage of original gross weight.

Table 4 - Effect of altitude on fruits and vegetables in tests D and E (high altitude) and test F (low altitude simulating pressurization). Lockheed decompression chamber, Burbank, California, November 22-23, 1948. [1]

Commodity	Test and altitude Ft.	Weight [2] Lbs.	Oz.	Weight loss [3] 1st Period Pct.	1st & 2nd Periods Pct.	Condition of produce after exposure to altitude test.
Figs	D-30,000	7	11	.8	.8	No injury, all lots soft-ripe, slightly shriveled.
	E-30,000	7	6	.8	2.5	
	F-10,000	7	9	.8	.8	
Check lot		12	1	.5	1.0	
Grapes	D-30,000	15	4	0	0	No injury. All lots incl. check showing some raisining also wetness from loose berries.
(Muscat)	E-30,000	15	6	0	0	
	F-10,000	16	1	.4	.4	
Check lot		14	15	0	0	
Grapes	D-30,000	16	12	0	.4	No injury. All lots dull, no wetness.
(Tokay)	E-30,000	19	12	.3	1.0	
	F-10,000	18	3	1.0	1.4	
Check lot		13	7	0	0	
Limes	D-30,000	10	10	0	0	No injury. All lots firm and bright.
	E-30,000	10	8	0	.6	
	F-10,000	7	10	0	.8	
Check lot		9	5	0	0	
Peaches						
(Freestone)	D-30,000	12	15	0	0	No injury. All lots incl. check ripe to soft ripe, few slightly shriveled.
	E-30,000	13	1	0	.5	
	F-10,000	12	12	1.5	1.5	
Check lot		12	11	.5	1.0	
Pears	D-30,000	15	8	0	0	No injury. All lots firm ripe.
(Comice)	E-30,000	15	10	0	0	
	F-10,000	15	3	0	.4	
Check lot		16	6	0	0	
Peppers	D-30,000	20	10	0	.3	No injury. All lots fresh, bright.
(Bell)	E-30,000	15	9	0	0	
	F-10,000	18	2	.3	.7	
Check lot		19	8	.3	.3	
Persimmons	D-30,000	14	11	0	0	No injury. All lots incl. check, soft, no splitting.
(soft ripe)	E-30,000	13	3	0	1.0	
	F-10,000	14	5	0	0	
Check lot		13	5	0	0	
Spinach	D-30,000	5	11	2.2	2.2	No injury. All lots incl. check slightly wilted.
(Packaged)	E-30,000	5	12	1.1	1.1	
	F-10,000	5	8	2.3	2.3	
Check lot		5	15	1.1	2.1	

Table 4 (Continued)

Commodity	Test and altitude Ft.	Weight[2] Lbs.	Oz.	Weight loss[3] 1st Period Pct.	1st & 2nd Periods Pct.	Condition of produce after exposure to altitude test.
Squash (Button)	D-30,000	15	11	1.2	1.6	No injury. All lots incl. check fresh but somewhat pitted.
	E-30,000	13	15	2.7	3.6	
	F-10,000	13	4	3.3	3.8	
Check lot		16	9	1.1	1.5	
Squash (Zucchini)	D-30,000	19	4	1.0	1.6	No injury. All lots fresh, bright.
	E-30,000	15	14	1.2	1.6	
	F-10,000	15	11	2.0	2.4	
Check lot		19	0	1.0	1.6	
Strawberries (Firm, 90% color)	D-30,000	6	1	2.1	3.1	No injury. Lots E & F somewhat dull.
	E-30,000	5	11	2.2	4.4	
	F-10,000	5	4	4.8	4.8	
Check lot		5	11	3.3	3.3	
Strawberries (Firm, full, color)	D-30,000	5	9	1.1	1.1	No injury. Lots D & E somewhat dull.
	E-30,000	5	8	2.3	3.4	
	F-10,000	5	7	2.3	2.3	
Check lot		5	14	1.1	2.1	
Sweet Corn (trimmed)	D-30,000	11	12	1.6	2.6	No injury. All lots fairly fresh, kernels plump.
	E-30,000	12	5	1.0	2.5	
	F-10,000	12	3	1.5	2.1	
Check lot		11	7	1.1	1.6	
Tomatoes (Large, ripe stems off)	D-30,000	19	1	0	.3	Possible injury. Skins cracked on several soft-ripe tomatoes in Lots E & F.
	E-30,000	19	8	0	.6	
	F-10,000	19	12	0	0	
Check lot		19	1	0	0	
Tomatoes (Small, ripe stems off)	D-30,000	14	1	.9	.9	No injury. All lots ripe, few soft ripe; no cracking of skin on soft ripe tomatoes.
	E-30,000	12	4	0	0	
	F-10,000	12	1	.5	.5	
Check lot		14	0	0	0	

[1] See Table 1 for differences in rate of climb, temperature, humidity, and duration of "flight." Low humidity for 6 hours in "pressurized" test F increased weight loss but other differences in "flight" conditions had little or no effect upon the produce.

[2] Lug boxes approximately half full.

[3] Fruits and vegetables weighed Nov. 22 just prior to altitude tests, re-weighed following "flight". Final weighing Nov. 24. All lots held in laboratory cold chamber at approx. 45° F., 65% r.h. following altitude tests.

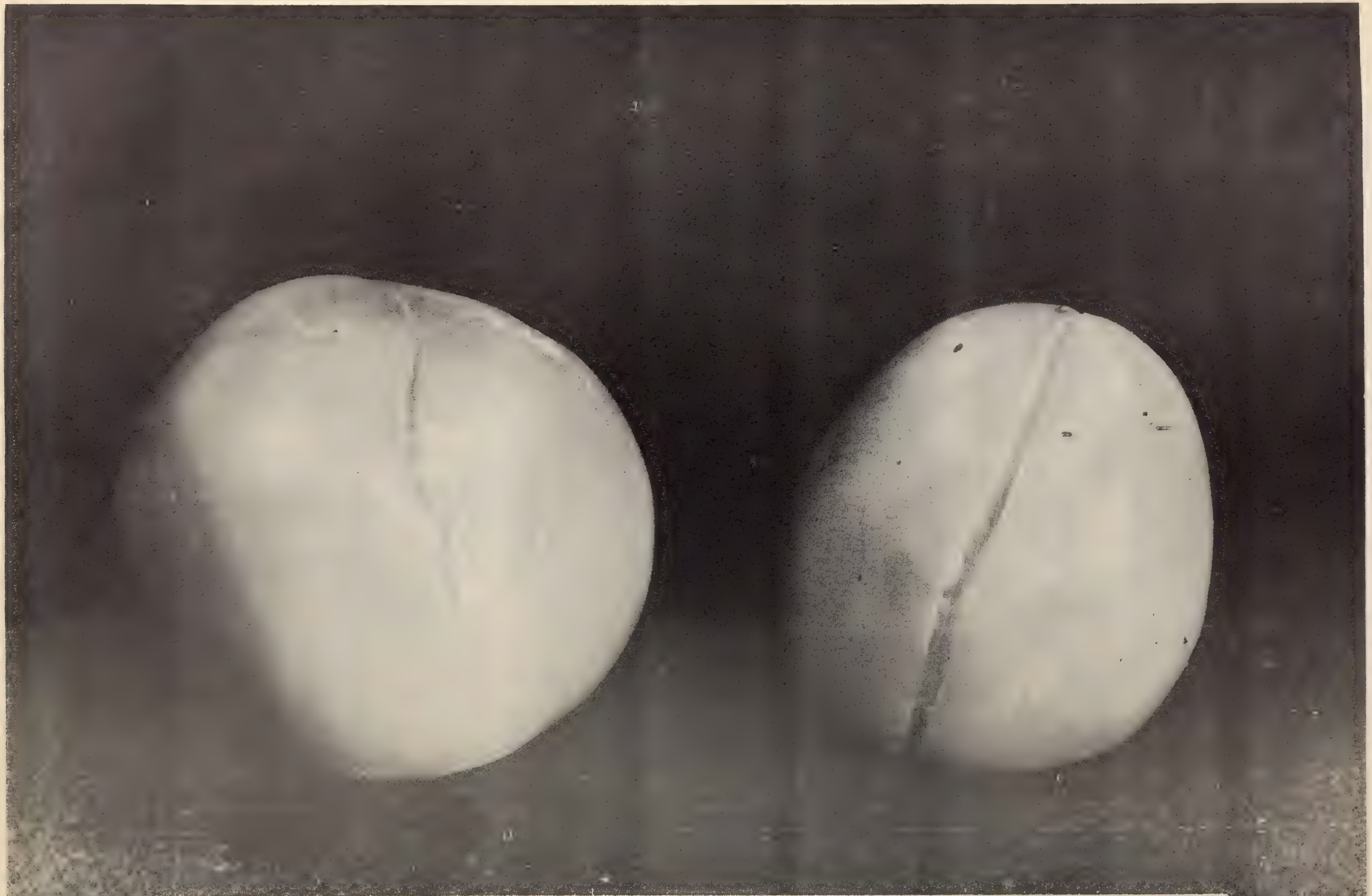

Figure 1. Ripe tomato and ripe persimmon split by swelling at about 48,000 foot altitude during simulated ascent of 5,000 feet per minute to 50,000 foot altitude (Test G).

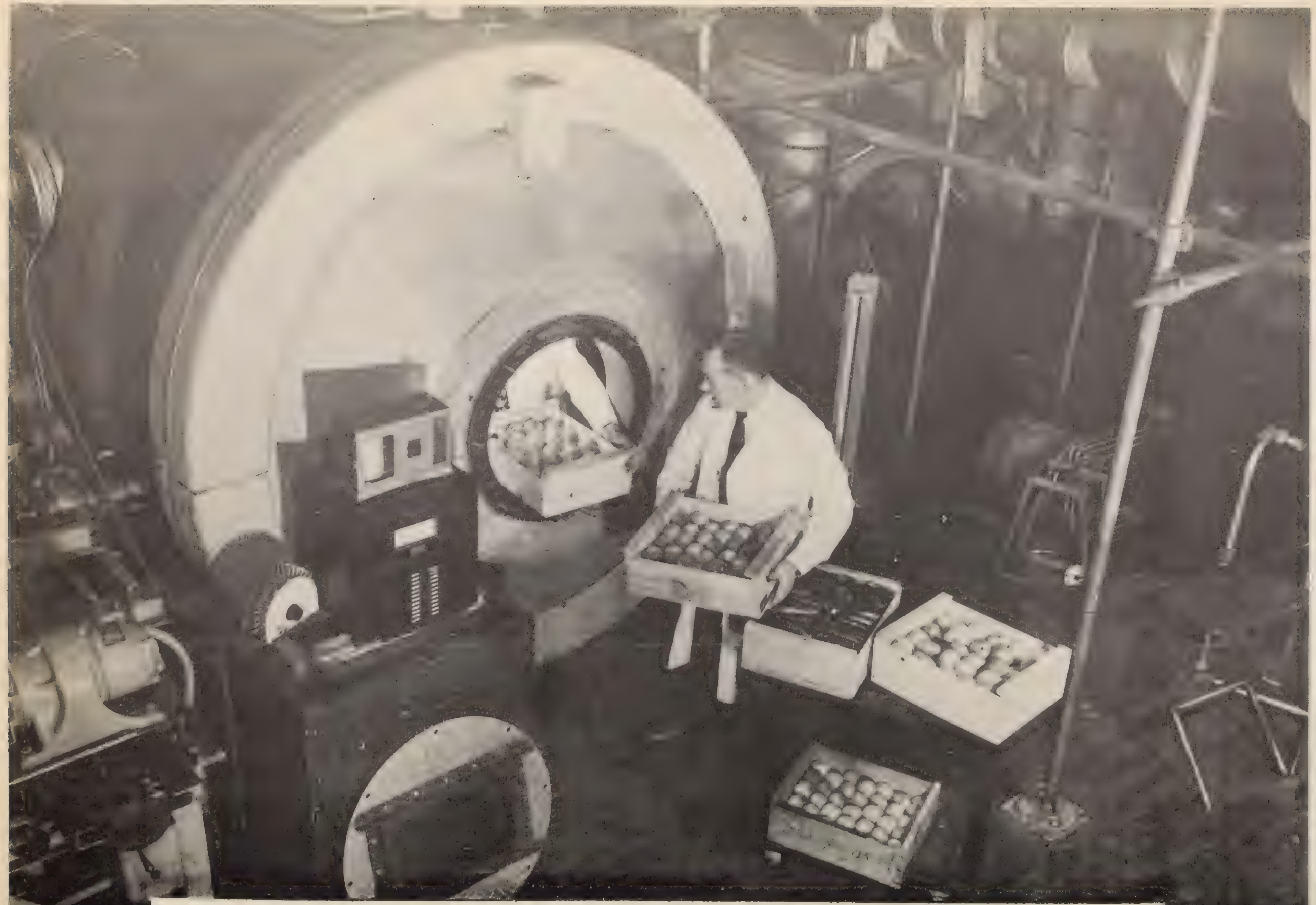

Figure 2. Loading decompression chamber with fruits and vegetables. Hygrothermograph and instrument for reading temperatures with thermocouples on table at left of photograph.

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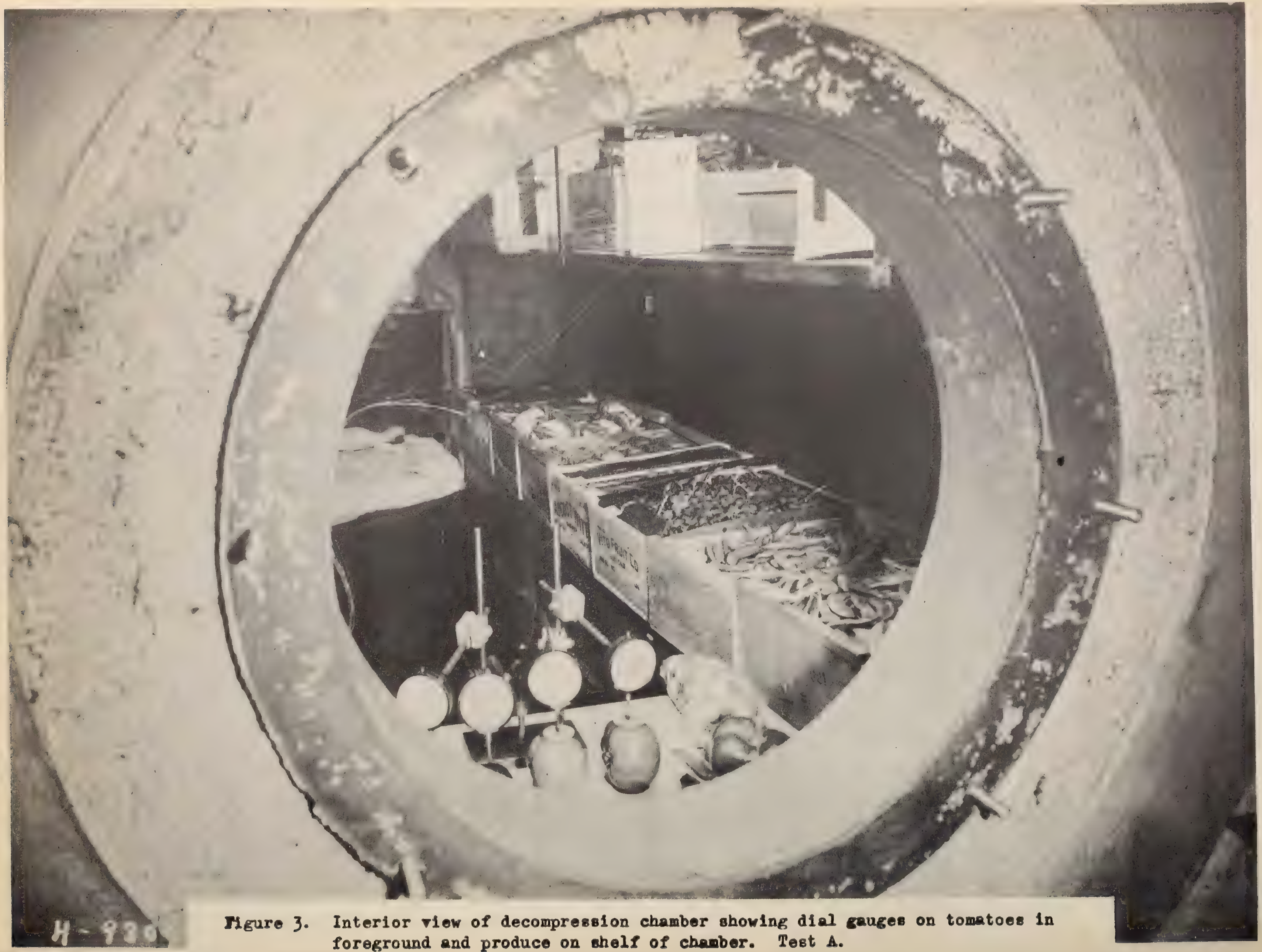

Figure 3. Interior view of decompression chamber showing dial gauges on tomatoes in foreground and produce on shelf of chamber. Test A.

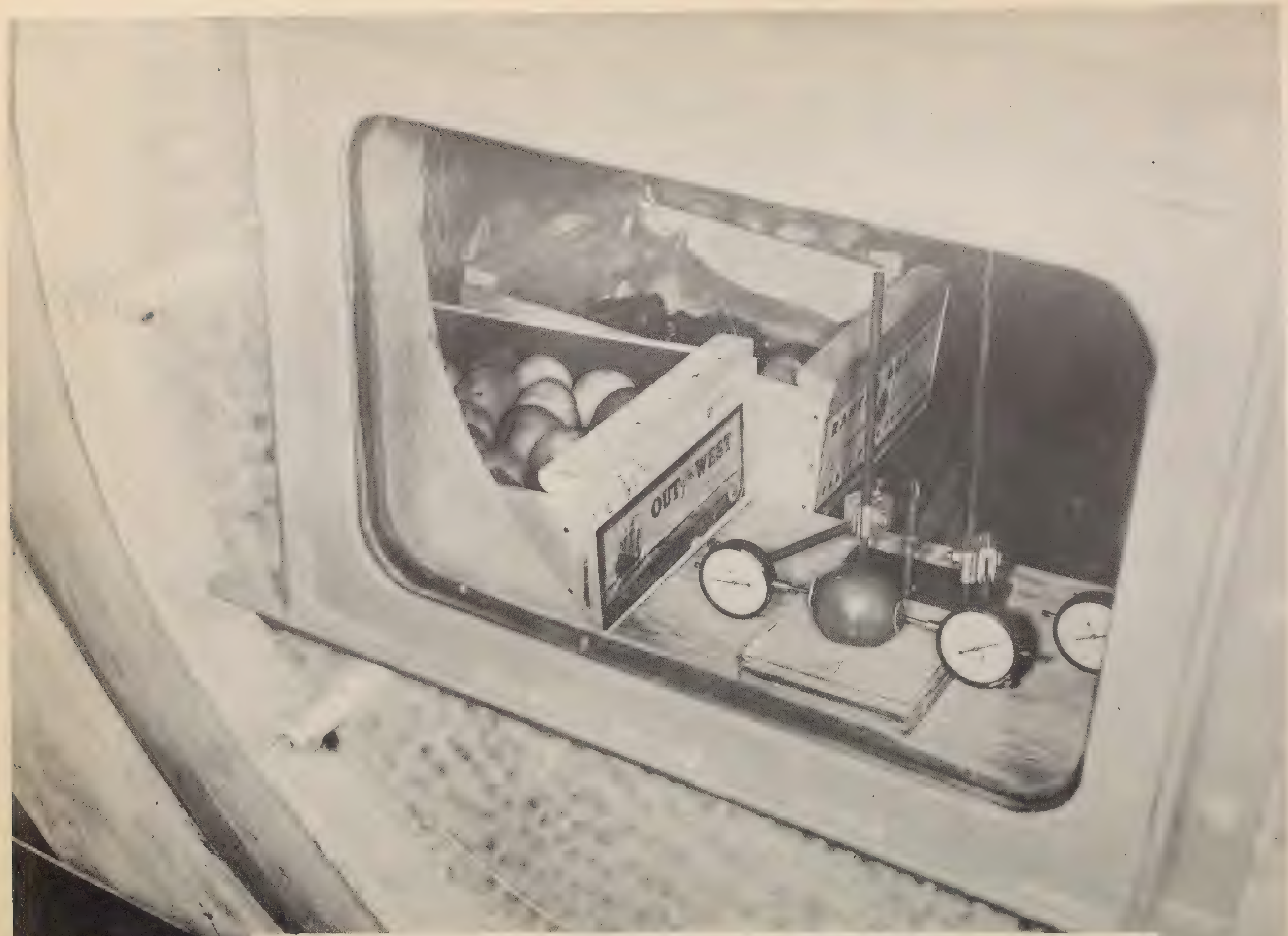

Figure 4. Close-up of dial gauges installed to show expansion and contraction of tomato, Test B.

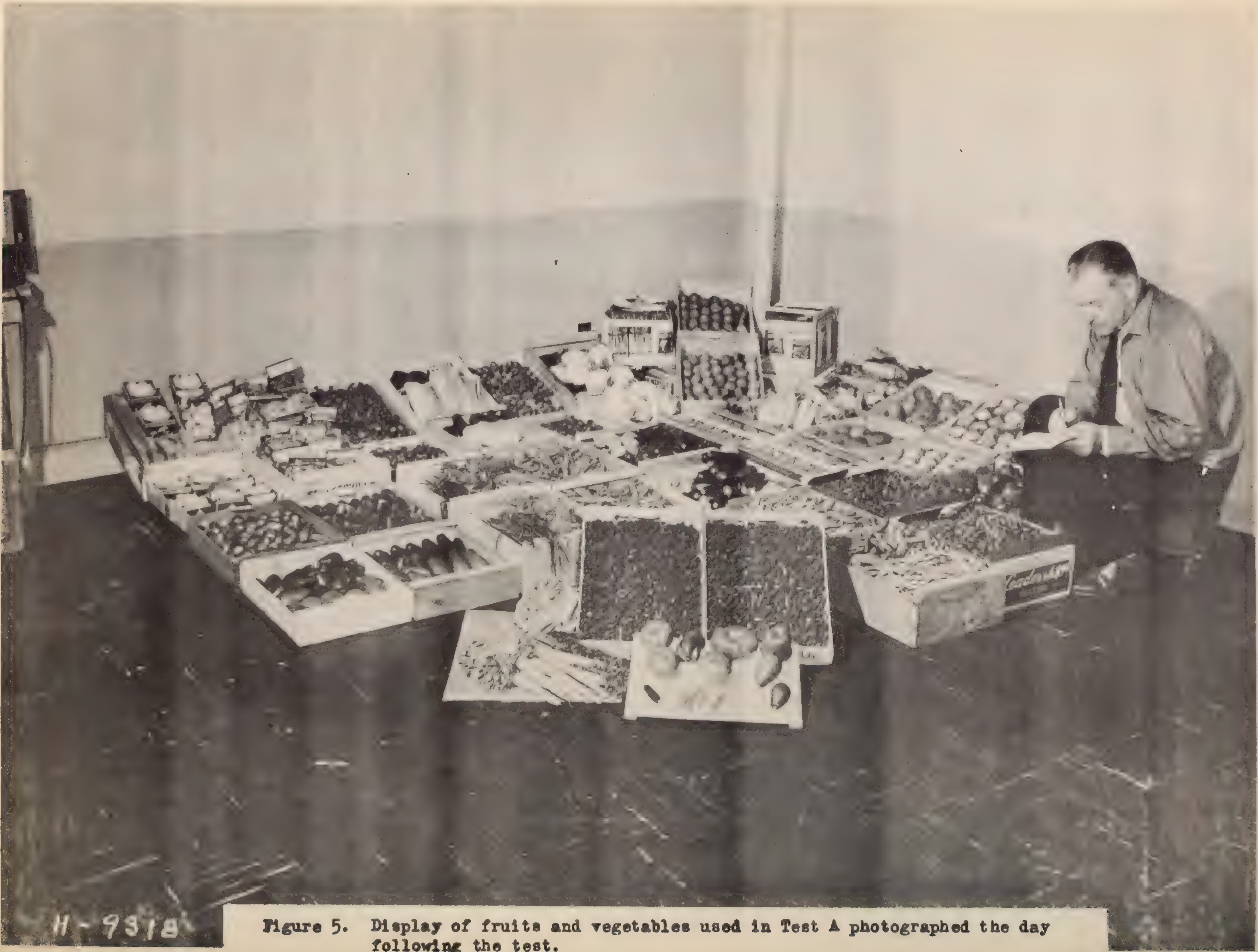

Figure 5. Display of fruits and vegetables used in Test A photographed the day following the test.

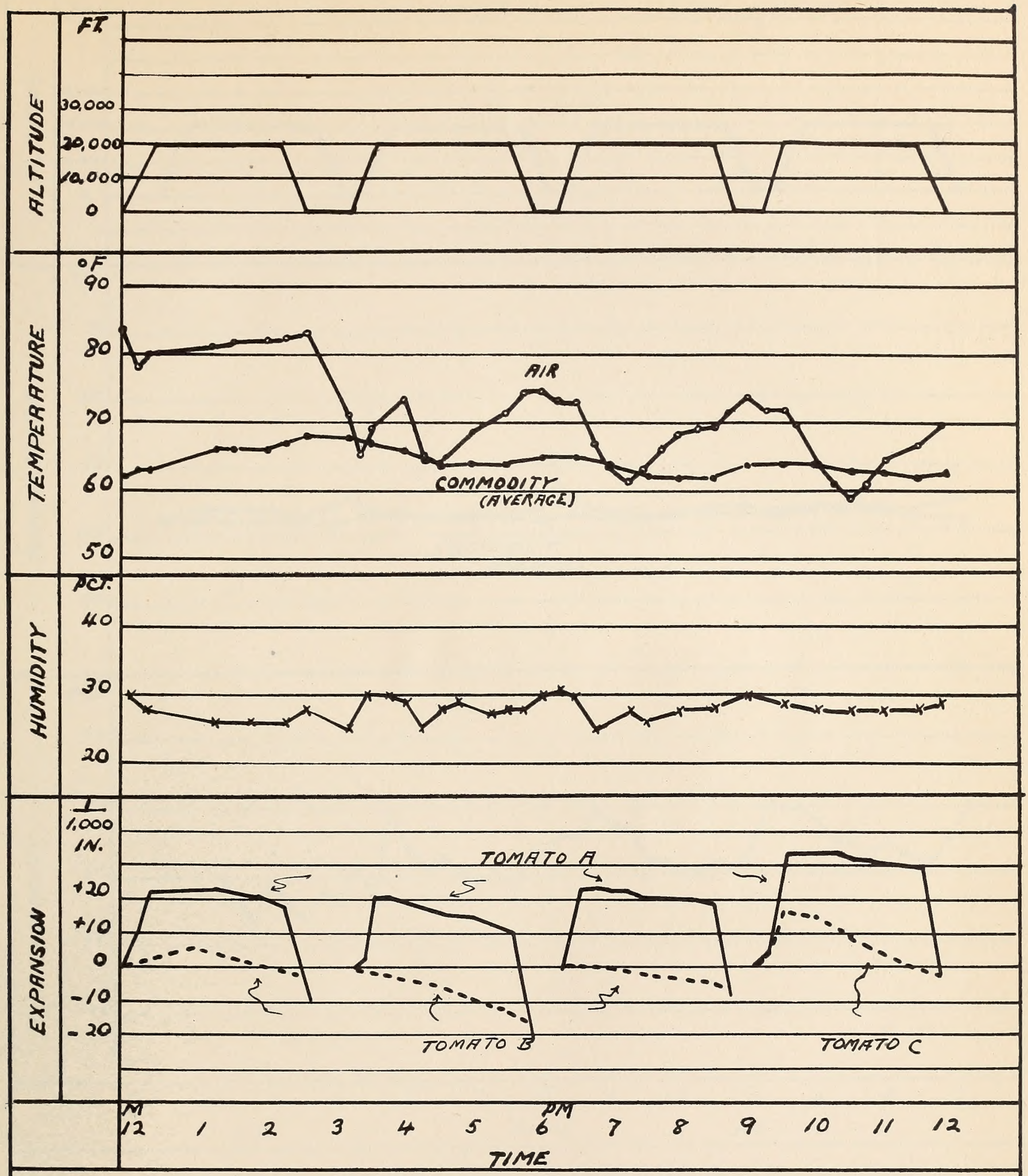

Figure 6. Test A in decompression chamber. Altitudes, temperatures and humidities fruits and vegetables were subjected to, and the expansion of tomatoes during the test, November 10, 1948.

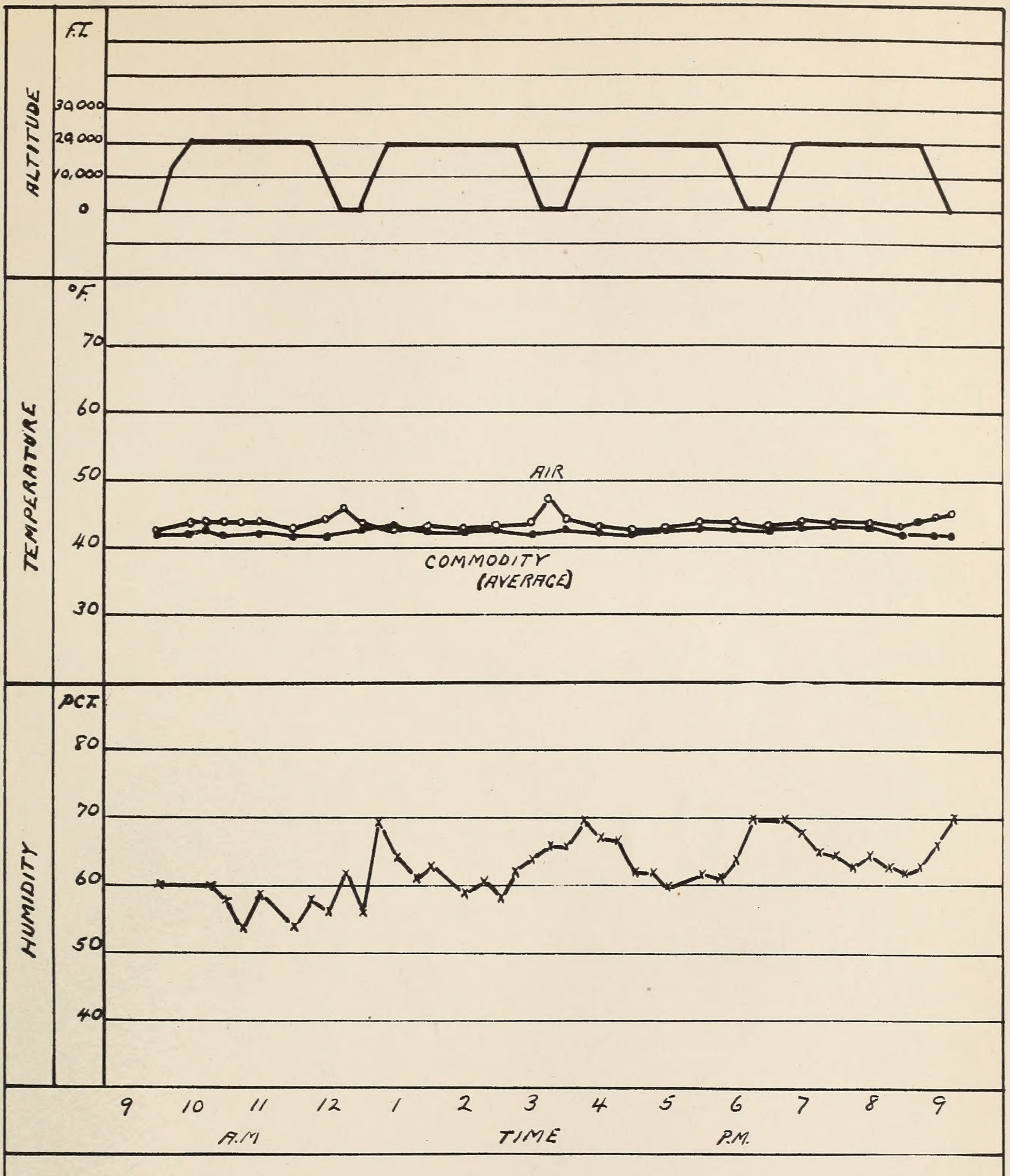

Figure 7. Test B in decompression chamber. Altitudes, temperatures and humidities fruits and vegetables were subjected to, November 16, 1948.